A STUDY ON THE EFFECT OF THE METALLIC JEWELLERY, THE HUMAN HEAD AND HAND ON SAR AND ANTENNA PERFORMANCE AT 2.4 GHz AND 5.8 GHz

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A project report submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Engineering (Electrical - Electronics & Telecommunications)

Faculty of Electrical Engineering
Universiti Teknologi Malaysia

JANUARY 2012

Specially dedicated to my beloved mom and dad,

To all my beloved brothers and sisters,

Thanks for the loves and support.

To my supervisor and co-supervisor,

Thanks for the supervision.

To all my friends,

Thanks for the support.

ACKNOWLEDGEMENT

In the name of Allah S. W. T, Most Gracious, Most Merciful. Praise to Allah, the Cherisher and Sustainer of the Worlds. With His permission, I have completed my Master Degree thesis and hope it will benefit the development of the Ummah in the next days.

Special thanks as well to my project supervisor, Dr. Noor Asmawati Samsuri for the guidance, encouragement and critics in completing the project. Without her continued support and interest, this project may not be the same as now.

Not to forget, to all lectures who have taught and sharing their precious knowledge especially Associate Professor Dr. Mohamad Kamal A. Rahim for the guidance as my project co-supervisor, thank you.

I would like to express gratitude to my beloved parents for all their sacrifices and moral supports. A million thanks to the rest of my family members and friends especially the members of P18.

I would like to thank Universiti Teknologi Malaysia (UTM) and the Malaysian Ministry of Higher Education for providing the Fundamental research Grant Scheme (FRGS Grant No: 78617).

ABSTRACT

Nowadays, we are moving towards the wireless and higher operating frequency for the communication trends. In addition, the wireless trend are always relate to the end-users devices which be used closed to the head, and hand. Furthermore, there is fashion amongst users to wear metallic items such as earrings. Hence, the effects of metallic items, head, and hand on the SAR at 2.4 GHz and 5.8 GHz and on the antenna performance are investigated in this project. The project results are based on the measurement and simulation using CST microwave Studio. The patch dipole antenna and wire dipole antenna have been used while the metallic items are modeled as λ/2 and λ/4 length straight-pin type earrings. The results have shown that the presence of head, metallic items, and hand affects the antenna performance (radiation pattern, radiation efficiency, and return loss) and SAR values and distribution on the body parts.

ABSTRAK

Masa kini, antara trend dalam bidang komunikasi ialah menuju penggunaan alat tanpa wayar dan juga beroperasi pada frekuensi tinggi. Tambahan pula,trend komunikasi tanpa wayar sering dikaitkan kepada pengguna yang mana akan menggunakannya hampir kepada kepala, dan juga tangan. Selain daripada itu, ada juga fesyen di kalangan pengguna yang memakai barangan kemas seperti subang dan cincin. Oleh itu, kesan kewujudan barangan logam, kepala dan tangan terhadap SAR pada frekuensi 2.4 GHz dan 5.8 GHz dan juga kesan kepada prestasi antenna dikaji dalam projek ini. Hasil kajian dikeluarkan melalui cara eksperimen dan juga simulasi menggunakan alat bantu computer, CST Microwave Studio. Antena yang digunakan ialah "patch dipole antenna" dan "wire dipole antenna" manakala subang pula dimodelkan sebagai pin lurus yang berkepanjangan $\lambda/2$ dan $\lambda/4$. Keputusan daripada projek menunjukkan kewujudan kepala, barangan metal, dan tangan mempengaruhi prestasi antena dan juga kuantiti dan taburan SAR dalam bahagian badan yang terlibat.

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LIST OF ABBREVIATIONS

RL	-	Return Loss
FR-4	-	Fire Retardant Type 4
mm	-	Millimeter
GHz	-	Gigahertz
SMA	-	Sub-Miniature version A
CST	-	Computer Simulation Technology
rms	-	Root mean square
SAR	-	Specific Absorption Rate

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Mobility is one of the important points or aspects in creating devices. Wireless devices have high mobility than wired devices. Because of that, the wireless devices usage increase from day to day especially for small devices such as mobile phones, and Bluetooth hands-free. Besides mobility, one of the aspects in creating wireless devices is has high capacity, or can carry more or high information. To ensure that the wireless devices can carry high information, the antennas are designed and fabricated at high operating frequency in order to be used in the devices. In addition, the trend of using high operating frequency causes users worrying about their health due to the electromagnetic field radiation at high frequency. That is because devices such as mobile phone is placed closed to the head and partially masked by the human hand and fingers causes the electromagnetic energy passes through the head and hand rather than being directly radiated. Thus, the users worrying about the effects of the high operating frequency radiation to their health, while the engineers thought that antenna performance may be affected.

There are trends amongst users to wear the metallic items such as earring, and necklace on their body. Hence, the issues of user's health and antenna performance become more complicated by considering the additional metallic items in-close proximity to the antenna. Because of that, the issues needed to be investigated including with the presence of metallic items. The interaction between the electromagnetic fields radiated by mobile phone, the human head, the hand have

been studied in [1-4], and interaction between the additional conductors such as external objects (wire-framed spectacles, hands-free) in [6, 8]. In recent years, researches start to focus on the effect of metallic [8, 9], the effect of hand, ring, earring on the SAR [21, 31] in their study.

1.2 Problem Statement

The trend in wireless telecommunication to use high operating frequency makes the users to worry about their health. They are worrying whether the electromagnetic field radiation will cause bad effect on their health such as cancer or not. Furthermore, the trends of wearing metallic items such as earring, and necklace will increase their chance to the health problems since mobile phone is usually placed close to the body part especially head while using it (talking mode) and partially masked by hand. In the engineer's vision, the antenna performance is important and it may be affected by the presence of the human body part. In addition, the presence of metallic items may degrade the antenna performance. Engineers concern on the antenna performance that disturbed by the presence of the human body part and metallic items.

Because of these issues, this project going to be studied about the effect of the metallic items, human head, and hand on specific absorption rate, SAR and antenna performance. The operating frequencies to be chosen are 2.4GHz and 5.8GHz in order to fulfill the trends of moving towards high operating frequency. The health effect caused by the radiation will be based only the SAR values and SAR distribution.

1.3 Objectives

The objectives of this research are to investigate the antenna performance and to observe the interaction between the antenna with and without the presence of human and metallic objects in close proximity to the antenna. The other objectives of this research could be summarized as follows:

- To investigate the effect of wearing metallic items on the SAR values and on the antenna performance such as radiation efficiency and radiation pattern.
- To determine the SAR inside the head/hand in the presence of metallic items, considering the separation distance between the antenna and head/hand model.

1.4 Scope of Research

The work for this research can be dividing into two main parts. The first part is simulation part and the second part is measurement part. Both of the parts can be summarized as:

1. Computer simulation using CST Microwave Studio
   1.1. Simulate and analyze the antenna characteristics in free space (e. g dipole, monopole)
   1.2. Investigate the effect by the presence of the head, hand, and metallic items (e. g earring).
   1.3. Analyze the amount of energy absorbed within the body part (SAR).
2. Antenna measurement
   2.1. Fabricate the antenna based on the simulations.
   2.2. Do measurement without and with the existing of head, hand, metallic items model (return loss measurement).

1.5 Hypothesis

The presence of human head and hand are expected to be affecting the antenna characteristics. The electric field in the head and hand also is expected to be influenced by the distance between hand and head to the antenna. In addition, the presence of the metallic items to be considered may cause additional effects on both antenna performance and SAR values. More over the antenna performance in radiation pattern, radiation efficiency may be degraded with the addition of hand in

close proximity to the antenna. Besides that, the antenna and head separation distance may change the electromagnetic field energy distribution on the human body part and influence the SAR values.

1.6 Overview of the Thesis

Chapter 2 outlines a brief summary of the theory of SAR, including the factors affecting the SAR, the standards and the limit guidelines set by expert groups. This chapter also discusses the interaction between the antenna with the human head, the hand and the metallic jewellery items worn on the head and the hand. Some of the human head and hand geometry and the phantom models commonly used are also discussed.

Chapter 3 presents the methodology of this study. The flow and the techniques, simulation tools that being used in order to finish the research also being discussed. The desired cases to be studied also discussed briefly in this chapter.

Chapter 4 presents the result from the research. The results are based on the simulation and measurement. The first part will be based on the antenna performance and the second part will be based on SAR on the human body part. There are three main antenna characteristics discussed in this chapter and they are return loss, radiation efficiency, and radiation pattern. For the measurement result will only discuss about the return loss of the antenna. The return loss results from measurement and simulation are going to be compared.

Chapter 5 concludes the research outcomes and recommendations for the future works in order to improve this project.

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